ENVIRONMENTAL PRODUCT DECLARATION

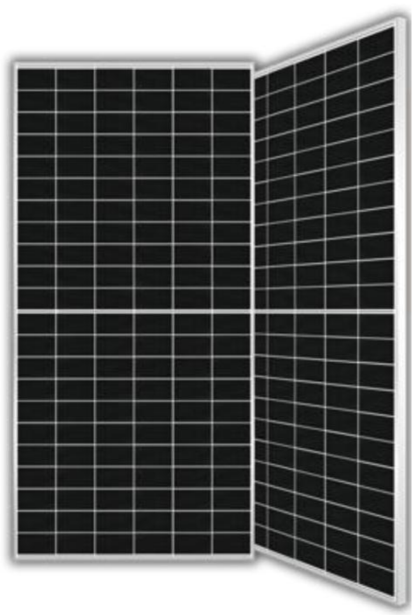
In accordance with ISO 14025:

PV Modules

From

ZNSHINE PV-TECH Co. Ltd.

Declared product:



Programme operator:	EPD China
Registration number:	EPD-CN-00002
Issued date:	2024-01-16
Valid until:	2029-01-16

ENVIRONMENTAL

PRODUCT

DECLARATION

Programme Information

EPD Owner	Name: Zhengxin Photoelectric Technology (Suqian) Co.,Ltd Contact information of EPD owner: No.1589,Guangzhou Road,Suqian Economic and Technological Development Zone,Suqian City eric.zheng@znshinesolar.com
Product Name	PV modules: ZXM7-SH108-xxx/M, ZXM7-SHLD144-xxx/M
Production Site	Suqian, Jiangsu Province, China
Identification of product	UNCPC 8541420000
Field of Application	Electricity generation
Programme Operator	EPD China Address: 3rd floor, Lane 320, Tianping Road, Xuhui District, Shanghai Website: www.epdchina.cn Email: info@epdchina.cn | secretary@epdchina.cn
LCA Practitioner	TÜV Nord (China) Ltd.
Responsibility	The EPD owner has the sole ownership, liability, and responsibility for the EPD
Comparability	EPDs within same category of product in different programme operator are not suggested to be compared. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible even applying the same PCR.
Validity	The EPD is published on 2024-01-16 and valid to 2029-01-16
LCA Software (version)	SimaPro 9.4.0.1 (2021)
LCI Dataset (version)	Ecoinvent v3.8 (2021)
Year(s) of Primary Data	08/2022-07/2023
PCR	EPDItaly 014: Electricity Produced by Photovoltaic Modules, version 1.1, 08/02/2022
Other Reference Document	EN 50693
Verification statement according to ISO 14025:	
Independent verification of the declaration and data according to ISO 14025:2010 ☐ internal ☑ external Third-party institution verification: <Siyao Chen, Bureau Veritas > Bureau Veritas is an approved certification body accountable for third-part verification. Approved by: EPD China	
Procedure for follow-up of data during EPD validity involves a third-party verifier: ☑ Yes ☐ No	

1 General Information

1.1 Company information

Founded in 1988, headquartered in Changzhou, Zhengxin(Suqian) is a high-tech photovoltaic enterprise specializing in the R&D, manufacturing, sales and EPC services and providing whole line solutions for product applications.

With 10GW capacity comprising 3 production bases in Changzhou, Suqian, and Yunnan. Zhengxin(Suqian) products and services cover more than 80 countries and regions through its sales and support network of 30+ subsidiaries around the world.

ZNSHINE has been recognized as the BNEF Tier 1 PV Module Manufacturer, PVEL Module Reliability Scorecard Top Performer, as well as a Most Influential PV Module Manufacturer and EPC Enterprise. The analyzed PV modules are produced by the manufacturing plant (Zhengxin Photoelectric Technology (Suqian) Co.,Ltd, short for Zhengxin(Suqian)(Suqian)) owned by the ZNSHINE Solar group.

Name and location of production site(s) within the organization

Table1. Location of PV module assembly sites

Module		
Component / Process	Manufacturing company name and address	Manufacturing country
Modules assembly	**Zhengxin Photoelectric Technology (Suqian) Co.,Ltd** No.1589,Guangzhou Road,Suqian Economic and Technological Development Zone,Suqian City	China

1.2 Scope and type of EPD

The system boundary considered in this LCA study is from the cradle to the grave. According to the PCR, the life cycle stage must refer to segmentation in the following three modules:

The upstream module contains extraction and processing of raw materials, including silicon, ingot block, wafer, PV cell with packaging, and the transportation of the raw material to the factory.

The core module According to the PCR, the core stage can be further divided into core-process and core-infrastructure.

The core-process includes ordinary and extraordinary maintenance of the module or plant, production and use of the fuel needed to inspect the plant, production, use and transportation of the materials required for maintenance (replacement parts or entire modules, replacement cables or other electrical connecting equipment).

The core-infrastructure includes the manufacturing of PV modules including its packaging materials, transportation of PV modules to the solar plant; construction of the solar plant including inverts and electrical auxiliary materials, de-construction and demolition of the solar plant transport to waste processing site

The downstream module covers the processes of the final waste processing and disposal. The transmission loss should also be accounted for in the downstream module. According to the PCR, the benefit and avoided loads beyond the product system boundary are not reported in module D separately within this study, nor will the benefit and loads be reported in other stages by following a cut-off allocation approach.

Figure 1 below illustrates the system boundaries for the PV modules, including raw material production and transportation, manufacturing, distribution, installation, and End-of-life. The figure demonstrates our tweaks:

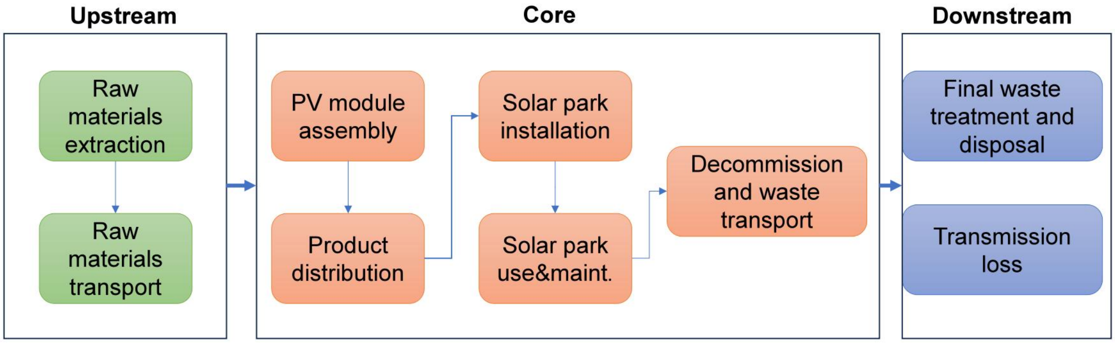


Figure 1 System boundary of PV modules

Detailed information on the segmentation for the upstream, core, and downstream modules are presented in the following. To better illustrate the contents within each module, life cycle stages interpretations and comparison according to the EN15804 is also provided.

Table 2: Division and declarations of life cycle stages according to the PCR and comparison to EN15804

PCR setting	Inclusion	Stages according to the EN15804	
Upstream module	X	A1	Raw material supply
	X	A2	Transport (to the manufacturer)
Core module	X	A3	Manufacturing
	X	A4	Transport
	X	A5	PV module installation
	X	B1	Use
	X	B2	Maintenance
	X	B3	Repair
	X	B4	Replacement
	X	B5	Refurbishment
	X	B6	Operational energy use
	X	B7	Operational water use
	X	C1	De-construction and demolition
	X	C2	Transport (to waste processing)
Downstream stage	X	C3	Waste processing
	X	C4	Disposal

Benefits and loads beyond the system	ND	D	reuse, recovery and/or recycling potentials

Note: X=Declared Module, ND=Module not Declared in this LCA study

2 Detailed Product Description

Description of the product

Within this EPD, four two types of PV modules from Zhengxin(Suqian) solar are analyzed, namely, ZXM7-SH108-xxx/M, a 10BB HALF-CELL Monocrystalline PERC PV Module; and the ZXM7-SHLD144-xxx/M, a 10BB HALF-CELL Double Glass Monocrystalline PERC PV Module. These PV modules are widely used to generate electricity on ultra-large ground power stations and Large-scale industrial and commercial projects.

Table 3. Different PV module products models

Serious (brand name)	Power output range (W)	Dimensions (mm3)	Weight (kg)	Cell number	Efficiency	Yearly degradation
ZXM7-SH108-xxx/M	390-420	1722×1134×30	20.5	108	21.51%	0.55%
ZXM7-SHLD144-xxx/M	520-560	2279×1134×30	32	144	21.67%	0.45%

Description of the production processes

A flowchart depicting the production process stages of Zhengxin Solar PV module products is shown in Figure 3 below. For simplification purposes, only the main stages of manufacturing are presented: raw material, and auxiliary processes considered in the LCA but not shown in the figure below since the manufacturing plant of Zhengxin only produces the PV panels. The silicon cells with the embodied ingot and wafer processing are purchased from the suppliers and should be categorized into the upstream stage.

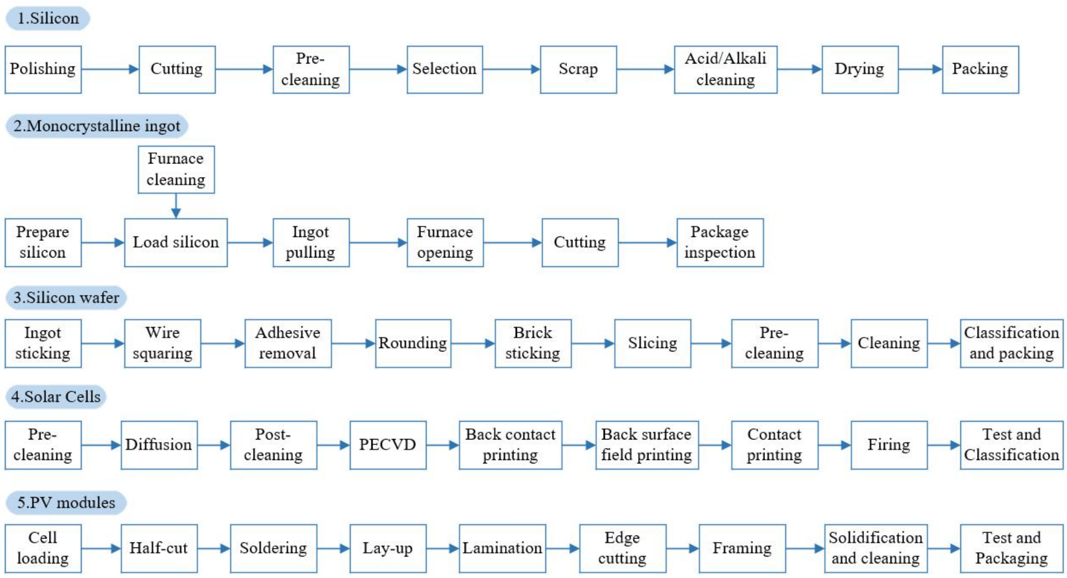


Figure 3 PV production processes of modules for Zhengxin

Table 4 Main product components and packaging materials per unit.

	ZXM7-SH108-xxx/M		ZXM7-SHLD144-xxx/M	
Product components	**Weight, kg**	**Weight-% (versus the product)**	**Weight, kg**	**Weight-% (versus the product)**
Cells	0.729	3.52%	0.972	3.02%
Front Solar Glass	15.000	72.49%	13.000	40.41%
Back Solar Glass	0.837	4.05%	13.000	40.41%
EVA at the glass side	0.812	3.92%	1.075	3.34%
EVA at backend	0.812	3.92%	1.075	3.34%
Bur bar solder	0.156	0.75%	0.203	0.63%
Connection solder	0.059	0.28%	0.059	0.18%
Junction box	0.103	0.50%	0.103	0.32%
Frame	1.876	9.07%	2.210	6.87%
Silicone seal for frame	0.258	1.25%	0.413	1.28%
Silicone seal	0.027	0.13%	0.027	0.08%
Code paper	0.001	0.00%	0.001	0.00%
Brand	0.001	0.00%	0.001	0.00%
Fixing tape	0.000	0.00%	0.000	0.00%
Flux	0.023	0.11%	0.030	0.09%
Sealing tape	-		0.004	0.01%
Total	20.694		32.173	
Packaging materials	**Weight, kg**	**Weight-% (versus the product)**	**Weight, kg**	**Weight-% (versus the product)**
EUR-pallet	0.903	74.33%	1.081	71.87%
Corrugated paper	0.250	20.59%	0.355	23.60%
paper angle bead	0.013	1.10%	0.013	0.89%
Paper card	0.022	1.82%	0.022	1.47%
Packaging strip	0.015	1.22%	0.019	1.25%
PE film	0.010	0.80%	0.012	0.78%
Packing buckle	0.002	0.14%	0.002	0.15%
Total	1.214		1.504	

No SVHC substances are employed in the current

Functional unit and Reference service life (RSL)

The functional unit is the product category unit to be referred to when determining environmental impacts. To assess the environmental impacts of different products, the functional units of these products must be equivalent to interpret the results.

In this study, the functional unit is 1 kWh of electricity generated as output from the solar PV plant. To derive such a value, the total energy output from the PV plant should be calculated. Once total energy has been calculated, the overall environmental impacts generated throughout the entire life cycle are divided by this value to return the results in the individual kWh produced. The total energy produced by the plant can be determined from the following equation according to the PCR

$$E_{tot} = E_{year} * RSL$$

E_{tot} represents the total energy produced by the plant (or, in an extreme case, by the individual module) during its entire life cycle;

E_{year} represents the energy produced annually by the plant. In the case of already installed plants, this figure can be calculated from the actual measurement of the energy produced. In the case of plants under construction but not yet operational, an estimate can be provided of the annual production of the plant, which will be a function of various parameters (average irradiation, exposure, temperature, optical factors, performance ratio/coefficient for losses, degradation rate, etc.) however known at the design stage.

RSL: stands for reference service life. According to the PCR, the RSL for PV modules is defined as 30 years.

3 LCA results

3.1 Environmental Impacts

The results of the underlying LCA are provided in this section as environmental impacts, resource use, output flows, and additional information on biogenic carbon.

Table 5: Environmental impacts

RESULTS OF THE LCA – Environmental impacts per functional unit for ZXM7-SH108-xxx/M					
Core indicator	**Unit**	**Total**	**Upstream**	**Core**	**Downstream**
Global Warming Potential total (GWP-total)	[kg CO2 eq.]	2.57E-02	1.68E-02	8.80E-03	1.13E-04
Global Warming Potential fossil fuels (GWP-fossil)	[kg CO2 eq.]	2.55E-02	1.69E-02	8.53E-03	9.23E-05
Global Warming Potential biogenic (GWP-biogenic)	[kg CO2 eq.]	2.17E-04	-6.74E-05	2.63E-04	2.09E-05
Global Warming Potential land use and land use change (GWP-luluc)	[kg CO2 eq.]	3.41E-05	2.02E-05	1.38E-05	5.63E-08
Depletion potential of the stratospheric ozone layer (ODP)	[kg CFC 11 eq.]	3.36E-09	2.64E-09	7.10E-10	1.14E-11
Acidification potential, Accumulated Exceedance (AP)	[mol H+ eq.]	2.05E-04	1.04E-04	1.00E-04	2.58E-07
Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	[kg P eq.]	1.54E-05	7.60E-06	7.74E-06	2.77E-08
Formation potential of tropospheric ozone (POCP)	[kg NMVOC eq.]	1.12E-04	6.94E-05	4.24E-05	1.85E-07
Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	[kg Sb eq.]	2.72E-06	1.05E-06	1.67E-06	3.86E-10

Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	3.15E-01	2.08E-01	1.06E-01	7.14E-04
Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	[m3 world eq. Deprived]	2.16E-02	1.69E-02	4.67E-03	2.01E-05

Table 6: Environmental impacts

RESULTS OF THE LCA – Environmental impacts per functional unit for ZXM7-SHLD144-xxx/M					
Core indicator	**Unit**	**Total**	**Upstream**	**Core**	**Downstream**
Global Warming Potential total (GWP-total)	[kg CO2 eq.]	2.61E-02	1.65E-02	1.59E-04	3.99E-04
Global Warming Potential fossil fuels (GWP-fossil)	[kg CO2 eq.]	2.58E-02	1.65E-02	1.58E-04	3.99E-04
Global Warming Potential biogenic (GWP-biogenic)	[kg CO2 eq.]	2.58E-04	-4.88E-05	9.27E-08	4.05E-07
Global Warming Potential land use and land use change (GWP-luluc)	[kg CO2 eq.]	3.40E-05	1.96E-05	6.46E-08	5.50E-08
Depletion potential of the stratospheric ozone layer (ODP)	[kg CFC 11 eq.]	2.58E-09	1.79E-09	3.49E-11	3.42E-12
Acidification potential, Accumulated Exceedance (AP)	[mol H+ eq.]	2.06E-04	1.03E-04	6.56E-07	1.97E-06
Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	[kg P eq.]	1.52E-05	7.29E-06	1.19E-08	7.58E-08
Formation potential of tropospheric ozone (POCP)	[kg NMVOC eq.]	1.14E-04	6.82E-05	6.43E-07	1.29E-06
Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	[kg Sb eq.]	2.64E-06	9.76E-07	5.40E-10	1.13E-09
Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	3.17E-01	2.01E-01	2.34E-03	3.61E-03
Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	[m3 world eq. Deprived]	2.14E-02	1.67E-02	8.08E-06	9.44E-05

3.2 Resource use and waste categories

Table 7: Resource use and waste categories

RESULTS OF THE LCA –Resource use and waste categories per functional unit for ZXM7-SH108-xxx/M					
Core indicator	**Unit**	**Total**	**Upstream**	**Core**	**Downstream**
Use of non-renewable primary energy excluding non-	MJ	3.11E-01	2.07E-01	1.03E-01	7.14E-04

renewable primary energy resources used as raw materials (PENRE)					
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (PERE)	MJ	8.50E-02	7.35E-02	1.15E-02	3.94E-05
Use of non-renewable primary energy resources used as raw materials (PENRM)	MJ	4.24E-03	1.20E-03	3.04E-03	0.00E+00
Use of renewable primary energy resources used as raw materials (PERM)	MJ	2.21E-04	2.21E-04	0.00E+00	0.00E+00
Total use of non-renewable primary energy resources (PENRT) (primary energy and primary energy resources used as raw materials)	MJ	3.15E-01	2.08E-01	1.06E-01	7.14E-04
Total use of renewable primary energy resources (PERT) (primary energy and primary energy resources used as raw materials)	MJ	8.53E-02	7.37E-02	1.15E-02	3.94E-05
Net use of fresh water (FW)	m3	6.82E-04	5.62E-04	1.20E-04	5.13E-07
Use of secondary material (SM)	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels (RSF)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels (NRSF)	m3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hazardous waste disposed (HWD)	kg	1.22E-05	9.87E-06	2.33E-06	1.65E-09
Non-hazardous waste disposed (NHWD)	kg	6.33E-03	2.47E-03	2.60E-03	1.26E-03
Radioactive waste disposed (RWD)	kg	8.11E-07	4.78E-07	3.28E-07	3.78E-09
Materials for recycling(MFR)	kg	6.28E-04	0.00E+00	2.29E-04	3.98E-04
Materials for energy recovery (MER)	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Components for re-use (CRU)	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported electricity energy (EEE)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported thermal energy (ETE)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 8: Resource use and waste categories

RESULTS OF THE LCA –Resource use and waste categories per functional unit for ZXM7-SHLD144-xxx/M					
Core indicator	**Unit**	**Upstream**	**Core**	**Downstream**	**Upstream**
Use of non-renewable primary energy excluding non- renewable primary energy resources used as raw materials (PENRE)	MJ	3.15E-01	2.04E-01	1.11E-01	4.29E-04
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (PERE)	MJ	8.42E-02	7.26E-02	1.16E-02	2.66E-05
Use of non-renewable primary energy	MJ	2.17E-03	4.81E-05	2.12E-03	0.00E+00

resources used as raw materials (PENRM)					
Use of renewable primary energy resources used as raw materials (PERM)	MJ	2.25E-04	2.25E-04	0.00E+00	0.00E+00
Total use of non-renewable primary energy resources (PENRT) (primary energy and primary energy resources used as raw materials)	MJ	3.17E-01	2.04E-01	1.13E-01	4.29E-04
Total use of renewable primary energy resources (PERT) (primary energy and primary energy resources used as raw materials)	MJ	8.44E-02	7.28E-02	1.16E-02	2.66E-05
Net use of fresh water (FW)	m3	6.75E-04	5.57E-04	1.18E-04	3.21E-07
Use of secondary material (SM)	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels (RSF)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels (NRSF)	m3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hazardous waste disposed (HWD)	kg	1.20E-05	9.74E-06	2.28E-06	5.81E-10
Non-hazardous waste disposed (NHWD)	kg	6.74E-03	2.44E-03	2.86E-03	1.44E-03
Radioactive waste disposed (RWD)	kg	8.31E-07	4.76E-07	3.52E-07	2.13E-09
Materials for recycling(MFR)	kg	6.50E-04	0.00E+00	2.34E-04	4.16E-04
Materials for energy recovery (MER)	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Components for re-use (CRU)	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported electricity energy (EEE)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported thermal energy (ETE)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4 Supplementary information

4.1 Calculation rules

functional unit:

In this study, the functional unit is 1 kWh of electricity generated as output from the solar PV plant. To derive such a value, the total energy output from the PV plant should be calculated. Once total energy has been calculated, the overall environmental impacts generated throughout the entire life cycle are divided by this value to return the results in the individual kWh produced.

Assumptions:

1. For missing background data, the substitution of missing data using a similar background data approach was taken to shorten the gap.
2. Besides transportation of PV modules, transportation of other infrastructures for the installation of the solar plant uses an assumed distance (100km) and vehicles (Euro 5 truck) for simplification purposes.
3. For PV plant construction, the study assumes that the mounting system is based on steel and its use (e.g. the mounting system and electric devices except for the inverter) is linearly associated with the total mass of the PV modules. The cables and inverters application are determined by the peak power of the PV modules.
4. Electricity used during the PV plant operation is assumed to be powered by the plant itself.
5. PV maintenance is determined by cleaning. This study assumes that PV module cleaning occurs one time per month. The water use is linearly associated with the dimension of the PV module.
6. PV modules are assumed to be replaced by 3%. The service life of the inverter is 15 years.
7. The electricity consumption during the de-construction of the PV plant (C1) is assumed to be the same to the electricity consumption of the construction stage (A5)
8. The transport distance for the PV modules to the waste treatment site is assumed to be the same value (500km) as in the e-waste treatment.
9. The waste processing for the PV modules is assumed to be done through mechanical treatment by shredding and separation.
10. The electronic components from the PV plant are assumed to be recycled at an 85% recycling rate.

Cut off rules

According to PCR, the definition of cut-off criteria allows some data from the inventory to be disregarded when such data is considered irrelevant to the study and would only represent an unnecessary burden in collecting data, without significantly altering the end result. Except for the exclusions listed in the PCR, no other specific cut-off criteria are applied.

Data quality

In this EPD, both primary and secondary data are used. Site specific foreground data have been provided by Zhengxin(Suqian). Main data sources are the bill of materials available on the enterprise resource planning. For all processes for which primary are not available, generic data originating from the ecoinvent v3.8 database, allocation cut-off by classification, are used. The ecoinvent database is available in the SimaPro 9.4.0.1 software used for the calculations. The ecoinvent v3.8 by cut-off classification system processes are used to model the background system of the processes. The raw material inputs are modelled with data from ecoinvent representing a global market (GLO) or rest-of-world (ROW) coverage. These datasets are assumed to be representative.

Allocations

Multi-Output allocation is based on a quantitative calculation of the resource consumption and the emissions for example in relation to the distribution of functions, physical properties, or economic aspects. Physical properties, such as mass and net calorific values., shall be preferred. Otherwise, economic aspects, such as man-hours, operating hours, or manufacturing cost may be used. In this study, mass allocation is applied in case of input partitioning is needed.

The allocation strategy for the EoL process per PCR follows the same strategy listed in EN15804. Thus, the “cut-off” strategy is applied. This scenario allocates the entire environmental impact of waste treatment procedures (from de-construction to waste processing) to the producer. The recycled materials, on the other hand, are burden-free. An important note is that when materials have reached a so-called “end-of-waste” state, the coverage of the waste processing is thus terminated. Any inputs/flows related to refining gross recycled materials for actual applications are beyond the product system boundary.

4.2 Scenarios and additional technical information

Description of the processes included in raw materials extraction, raw materials transport and PV assembly.

Raw materials extraction includes materials needed to produce ingot, wafer, cell, and PV modules. Ingot, wafer, and cell can be regarded as the intermediate products along the PV module production line. The raw materials extraction for the two types ZNSHINE PV modules are similar. The PV cells as well as the upstream ingot and wafer are manufactured by Tongwei Co. Ltd., a major PV cells supplier in China. Thus these background data are also retrieved from the PV module producers. Therefore, ingot, wafer, and cell processings are sourced from the Ecoinvent datasets “silicon production, single crystal, Czochralski process, photovoltaics RoW”, “single-Si wafer production, photovoltaic RoW” and photovoltaic cell production, single-Si wafer RoW, respectively. The only changed thing is the electricity profile switching from the combination of electricity profiles in the original Ecoinvent dataset toward the electricity mix in Sichuan.

Raw materials transport: Concerning raw material transportation, all the raw materials are sourced from domestic suppliers and are transported by truck, EURO5 is used for modeling in this study. The 16-32t transportation type scenario is assumed. The study applies an aggregated approach to raw materials transportation summarizing all the transport data by multiplying the weight and the transportation distance.

PV module manufacturing: The PV modules involves multiple manufacturing sites for the PV module production and their predecessors. The manufacturing sites are listed in the Table 5. However, it should be noted that Zhengxin(Suqian)(Suqian) is only responsible for the production of the PV modules. The upstream ingot, wafer and cell productions are implemented by Tongwei Co. Ltd. The cells are purchased by Zhengxin(Suqian)(Suqian) to assemble the PV panels. The selected ecoinvent processes in the LCA model have a global representativeness, due to the unclear origin of each component. In this way, a conservative approach has been adopted.

Table 9: Geographical boundary for the PV production and its upstream

	Ingot	Wafer	Cell	PV modules
ZXM7-SH108-xxx/M	Leshan city, Sichuan	Leshan city, Sichuan	Chengdu City, Sichuan	Suqian city, Jiangsu
ZXM7-SHLD144-xxx/M	Leshan city, Sichuan	Leshan city, Sichuan	Chengdu City, Sichuan	Suqian city, Jiangsu

Product distribution: The products are assumed to be transported to Haikou, China for application.

Table 10: Product distributions for the PV modules

	ZXM7-SH108-xxx/M	ZXM7-SHLD144-xxx/M
PV Mass (kg)	20.5	32
Corresponding packaging	1.21	1.5

Suqian-Haikou	2182	2182

Description of the processes for others

Installation: The Bill-of-materials (other than modules) for installation include mounting, inverter, and PV cables. The transformer is not included in the LCA of the PV installation system since it is part of the grid distribution and transmission system. The study utilizes the real-ground mounted large-scale PV plant in China as the reference to derive the bill of materials for PV module installation. The scaled PV plant per PV module is provided in the following table to illustrate the final composition with the mounting system and substation.

Table 11: The PV plant scaled by PV module

PV module category	**Unit**	**ZXM7-SH108-xxx/M**	**ZXM7-SHLD144-xxx/M**
Mass	kg	20.5	32
Nominal power	W	410	550
PV modules mounting system			
Steel	kg	14.35	22.40
Substation			
Copper	kg	1.03	1.38
PP	kg	1.13	1.51
Inverter	kg	2.95	3.96
oil	kg	0.23	0.31
Total Mass	kg	40.18	61.56
Erection process			
Electricity	kWh	0.025	0.033
Diesel	MJ	5.49	7.37

Uses and maintenance: the reference service life (RSL) of the PV module is assumed to be 30 years. The energy production is simulated by the technicians in Zhengxin(Suqian) through PVsyst 7.2.16 software. Various types of array losses are considered, including thermal losses, degradation loss, LID degradation loss, module quality loss, mismatch loss, DC wiring loss, etc. Energy production in RSL is simulated according to the power station in Table 12. The PV plant maintenance is assumed to be done once per month within a 10km driving distance. The reference PV plant applies a 0.765L/m2 water use rate. This factor is used in this study.

Table 12: Power station information for simulation

Item	Value
Location	Haikou-China
Peak power of the plant	50MW
Latitude	19.08°N
Longitude:	108.69°E
Altitude	25
Nominal solar irradiance	1556.7 kWh/m2/year

Decommission and waste transport: For the end-of-life stage, the De-construction of the PV plant during the disposal stage is assumed to mainly consuming electricity, and the electricity consumption is assumed the same as the construction stage, 500km transportation distance from plant site to waste treatment site is assumed. After deinstallation, the PV is divided into modules, mounting systems and waste electronics. The steel mounting system is 100% recycled by assumption. The WEEE, which mainly consists of substation and inverter, is projected to be treated through shredding and sorting (Ecoinvent dataset, Waste electric and electronic equipment {GLO}| treatment of, shredding | Cut-off, U). Since there is lack of existing data of recycling rate for PV module and inverter, this study refers to legal requirements issued by Waste Electrical and Electronic Equipment (WEEE). In 2012/19/EU-Article 11 & ANNEX V, the required recycling rate is 85% for these waste electronics. Therefore, 15% of WEEE ends up with waste disposal. Further considering a 55%/45% incineration/landfill composition, the study obtains an 8.25% incineration and 6.75% landfill for the WEEE. The PV module is mainly composed of inert silicon materials and aluminium frames. The aluminium frame is assumed to be recycled and the remaining are landfilled.

Table 13 Waste treatment scenario

	Recycling	Incineration	Landfill
PV module	8%	0%	92%
Steel metals	100%	0%	0%
WEEE	85%	8.25%	6.75%

4.4 Other optional additional environmental information

In this LCA, different electricity mix datasets are modelled based on the current Ecoinvent database. For example, the electricity production mix in Sichuan is sourced from "electricity, high voltage, production mix CN-SC" modeled in the Ecoinvent database, this datasets are used with adjustment the transmission and distribution of lost of Sichuan's grid. The PV modules are assembled in the manufacturing site in Suqian where part of the electricity is supplied by a on-roof PV photovoltaics array with a clear track of the flow. Therefore a residual mix is constructed for manufacturing plant in Suqian with 73.1% of the electricity purchased from the national grid and 26.9% of electricity sourced from the on-roof PV station Therefore their electricity product mixes are applied with adjustments for the respective grid loss. The electricity production mix and transmission loss are based on the China Energy Statistics Yearbook 2021. The detailed information can be found in Table 14

Table 14 Electricity profiles applied in the LCA

Province involved	Process	Production mix	Technology year	Transmission loss
Sichuan	Ingot，wafer and cell production	Electricity, high voltage {CN-SC}| electricity, high voltage, production mix | Cut-off, U	2020	8.04%
Jiangsu	Module assembly	Electricity, high voltage {CN-JS}| electricity, high voltage, production mix | Cut-off, U	2020	3.32%
		Electricity, low voltage {CN-JS}| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | Cut-off, U	2021	/

An additional indicator is the Return On Energy (RoE). This parameter gives an estimate of the efficiency of the photovoltaic park's solar energy production.

$$RoE = \frac{E_{invested}}{E_{produced,annual}}$$

Where $E_{invested} = PENRT + PERT$. $E_{produced,annual}$ is the electricity generated on the yearly basis.

Table 15 Yearly produced electricity

Year	ZXM7-SH108-xxx/M (kWh)	ZXM7-SHLD144-xxx/M (kWh)
1	564.85	758.38
2	562.66	755.44
3	560.22	752.17
4	557.46	748.47
5	554.38	744.44
6	550.89	739.76
7	546.83	734.53
8	542.69	729.09
9	538.55	723.64
10	534.49	718.20
11	530.75	713.30
12	527.43	708.83
13	524.34	704.58
14	521.42	700.55
15	518.66	696.74
16	516.39	693.48
17	514.60	690.75
18	512.73	687.81
19	510.54	684.65
20	507.94	680.95
21	504.21	676.05
22	499.26	669.95
23	493.82	663.20
24	488.05	656.12
25	481.97	648.83
26	476.12	641.53
27	470.36	634.45
28	464.51	627.37
29	458.67	620.08
30	452.66	612.78

Table 16 RoE for different PV modules

	ZXM7-SH108-xxx/M	ZXM7-SHLD144-xxx/M
$E_{invested}(MJ)$	6195.83	8341.018
RoE	3.72	3.82

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ENVIRONMENTAL

PRODUCT

DECLARATION